Research on Double Strengthening Ring in Transmission Drum of Belt Conveyor

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Abstract

As the main force transfer component of belt conveyor, transmission drum is indispensable in the composition of belt conveyor. The contact between the transmission drum and the conveyor belt transfers the friction driving force, and its service life seriously affects the safe and efficient production of the coal mine. However, the traditional transmission drum has many failure problems, and the strengthening ring is the main form of the drive drum strengthening. It has good effect on improving the performance of transmission drum. Based on the establishment of belt conveyor transmission drum model and the finite element analysis method, this paper verifies the effect of the reinforcing ring, and on this basis, further explores the effect of the double stiffening ring with different spacing on the maximum deformation of the transmission drum. In order to provide the theoretical basis for the standardization and optimization design of the rectangular stiffening ring of the transmission drum, the data analysis is carried out by means of Origin.

Keywords

Belt conveyor,transmission drum,strengthening ring,ansys.

1. Introduction

Belt conveyor is the most efficient and widely used material handling machine in the field of continuous transportation. Its application in coal mine has developed towards the direction of long distance, high power and high speed. As the main force transfer component of belt conveyor, the service life of transmission drum greatly affects the safe and efficient operation of belt conveyor, and then affects the production efficiency of the whole coal mine. The main failure form of transmission drum are crack, large deformation, fracturing and so on. Guo Zhiguo, Li Yunhai and others have analyzed the stress and deformation of the drum under preloading and working load. It is concluded that the main failure form of the shell is the staggered tensile pressure when rotating. Shrinkage deformation; Liu Tiegang analyzed the relationship between the number of stiffened rings and the principal stresses of the cylinder, and studied the relationship between the inner diameter of the strengthened ring and the diameter of the tube; Wang Chunhua, Fan Changda and others designed the stiffening rings with different cross-section shapes, The effect of strengthening ring with triangular section is better than that of rectangular section and trapezoidal section. In this paper, the effect of the cross section size of rectangular reinforced ring on the maximum deformation of the roller is studied by finite element analysis, aiming at the failure of the middle part of the roller due to excessive deformation in the course of using the transmission drum, and the finite element analysis method is used to study the effect of the section size of the rectangular reinforced ring on the maximum deformation of the cylinder. Furthermore, the double stiffening ring pairs with different spacing are further explored. Enhance the impact of the effect.

2. Mechanical Model of Drive Drum

2.1 Structural Parameters of Transmission Drum

Due to the development of welding technology, the design and manufacture of roller has been gradually developed into cast-welding type, that is, the radial plate and shell are cast together, and the radial plate and shaft are connected by expansion sleeve.In an engineering practice, the structural parameters of the drive drum are as follows (unit: mm)

Table 1 Parameters list of the drum

Rub factor	Radials	Drum length	Drum diameter	Shell thickness	Radials thickness	Bearing block centerline spacing	Expansion sleeve width
0.3	1232	1400	1000	14	110	2050	96

In this paper, the strain of the cylinder shell is mainly studied. Assuming that the tension static arc of the conveyor belt on the drum is 30 degrees and the sliding arc is 180 degrees, the tension magnitude of the drum is assumed 70KN. A model is established in Ansys Workbench DM, as shown in Figure 1.

2.2 2.2 Grid Partitioning and Constrained Load

The cylinder model is meshed with tetrahedron mesh method, the bearing position is fixed and the pressure load and friction load are applied in 180°sliding arc of the shell, the pressure load is radial direction, and the friction direction is tangent direction of circular arc. There is no friction in the static arc and the effect is shown in Fig. 2.

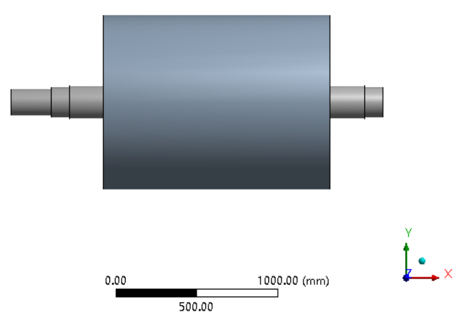


Fig.1. Transmission drum model

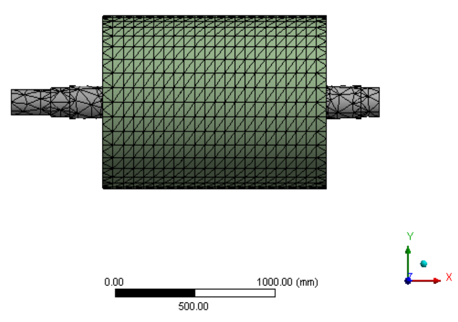


Fig.2. Grid effect

The main load on the transmission drum is the radial pressure load and the tangential friction load imposed by the conveyor belt, in which the radial pressure changes continuously along the circumferential direction, and the load along the circumferential direction conforms to the Euler's formula, as shown in formula (1), (2). Because of the defects in the manufacture of the conveyor belt and the fact that the conveying material is often located in the middle of the conveyor belt, the radial pressure of the conveyor belt to the shell of the conveyor belt is not uniform in the axial direction, but the calculation of the uneven pressure is extremely complicated. It is generally considered that the radial pressure on the transmission drum is uniformly distributed along the axial direction.

The pressure load and friction load are applied in the 180° sliding arc of the shell, the pressure load is in the radial direction, the friction direction is along the tangent direction of the circular arc, there is no friction force in the static arc, only the pressure load is applied.

Ansys Workbench can not apply a load varying exponentially in a finite element load, and the load applied shall be uniformly distributed or linearly varied. Therefore, when the radial pressure is applied, the envelope angle is discretized in the range of the envelope angle, and each section is calculated and analyzed. Assuming that the pressure varies linearly at every 10°interval, the exponential function is fitted by Matlab, with the expression of linear function, and the pressure of continuous variation is replaced by the pressure of discrete variation. The fitting effect is shown in Fig. 4. The friction force belongs to tangential distribution. The direction of the friction force is determined by setting the independent rotating coordinate system of the nodes. The coordinate system is set as shown in figure 5. The effect of applying surface load is shown in figure 7.

$$P = \frac{S_\theta}{BR} \quad (1)$$

$$S_\theta = S_l \cdot e^{\mu\alpha} \quad (2)$$

P ——Radial pressure on transmission drum

S_θ ——Tension at any point in the conveyor belt

S_l ——Tension of conveyor belt at separation point of transmission drum

α ——Envelope angle

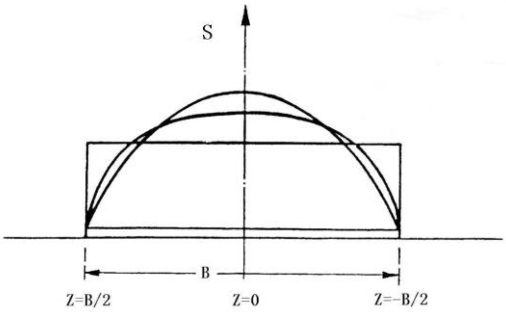


Fig.3. Axial force diagram of transmission drum

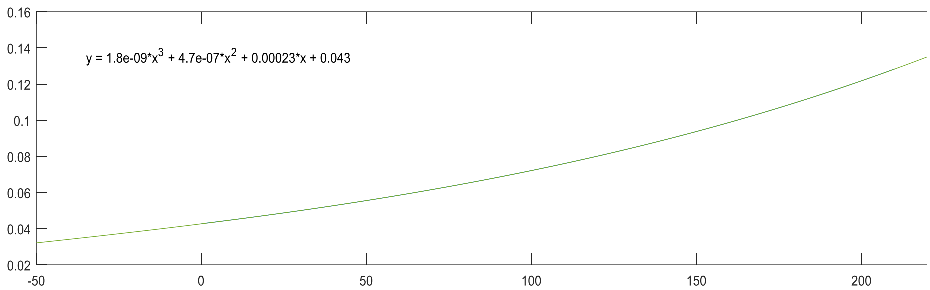
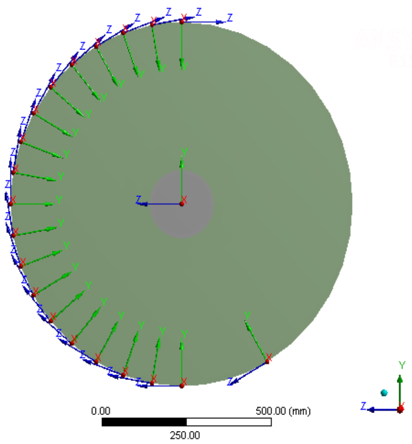


Fig.4. Fitting curve of radial load



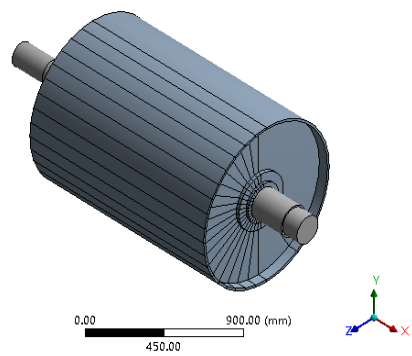


Fig.5. independent rotation coordinate system Fig.6. Envelop angle discrete graph

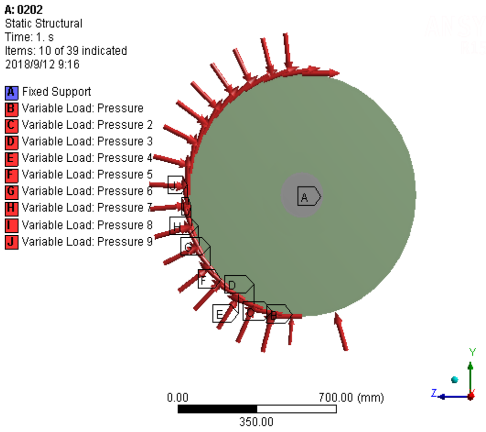


Fig.7. Load effect

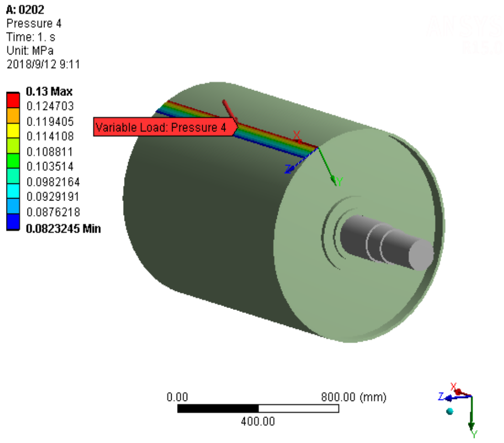


Fig.8. Pressure load of single module

2.3 Analysis of results

On the basis of the preprocessing of the finite element analysis, the displacement and stress of the transmission drum without the reinforcing ring are obtained by solving the problem.

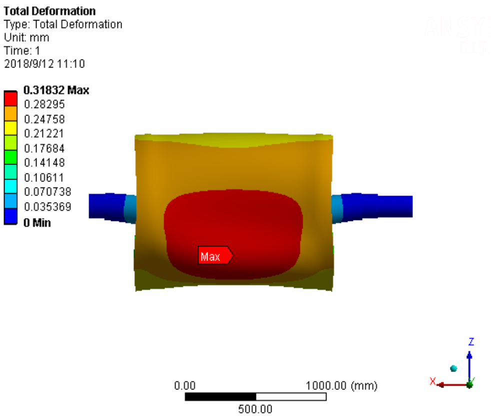


Fig.9. Total deformation without ring

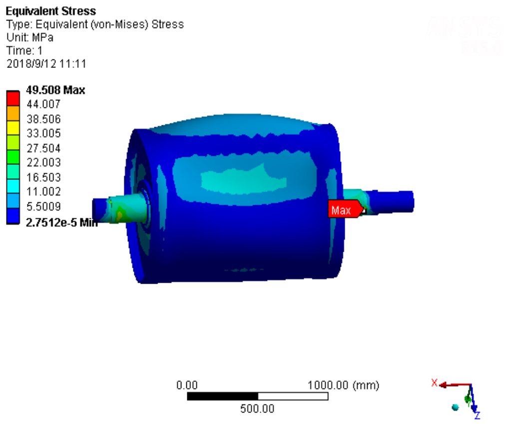


Fig.10. Equivalent stress without ring

①It can be seen from the equivalent displacement nephogram of the drum without stiffening ring in Fig. 9 that the maximum deformation of the drum appears in the middle of the drum shell and the maximum deformation is $0.31832mm$ in the middle of the drum shell.

②From the equivalent stress cloud diagram, it can be seen that the stress of the transmission drum is mainly concentrated in the shaft section between the bearing and the expansion sleeve, and in the middle of the cylinder shell. The maximum stress is $49.508MPa$.

3. Strengthen the effect of ring

3.1 Single stiffening ring

The rectangular stiffening ring is added in the middle of the drum. The cross section size of the rectangular stiffener ring is as follows: width $b = 14mm$, height $h = 14mm$, and other parameters. The displacement and stress cloud diagram are obtained by adding the same constraints and loads.

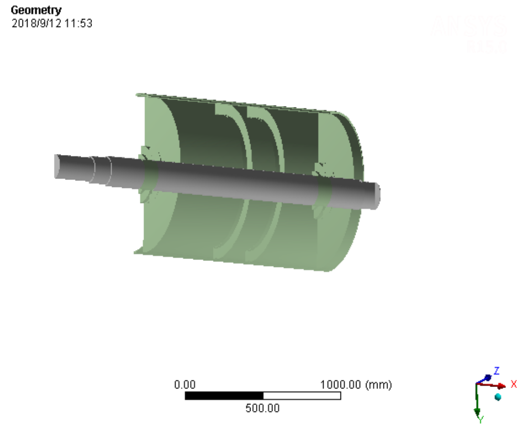


Fig.11. drum with double ring

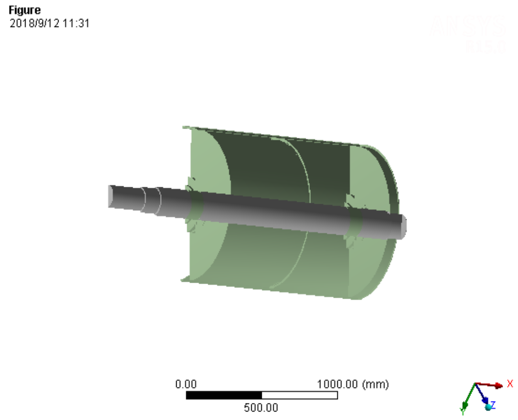


Fig.12. drum with single ring

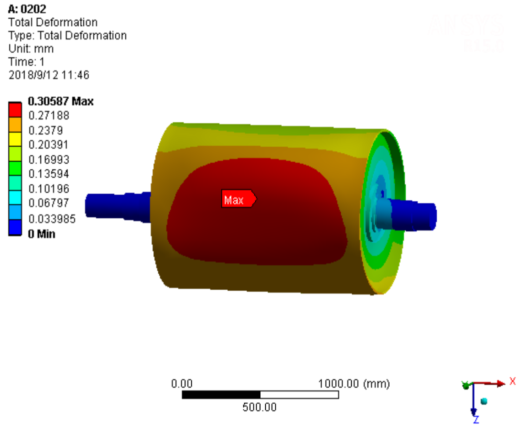


Fig.13.Total deformation with ring

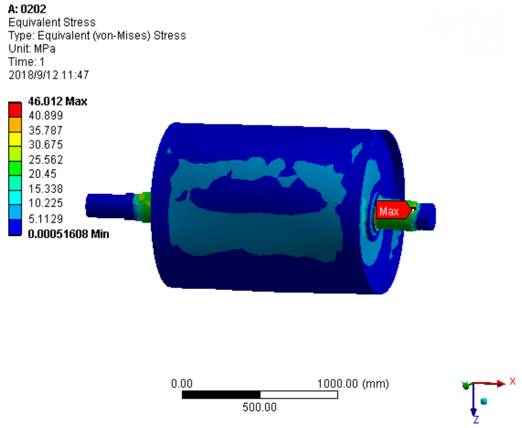


Fig.14. Equivalent stress with ring

It can be seen that adding rectangular reinforcing ring in the middle position can reduce the maximum deformation of the transmission drum. The maximum deformation of the drive drum with rectangular reinforced ring is still in the middle of the cylinder shell. The maximum deformation is reduced by 3.91% compared with the drum without reinforcing ring device.

3.2 Double stiffening ring

The width of the stiffening ring is four times that of the shell, $b = 56mm$,The height is 5 times the thickness of the shell, $h = 70mm$.

One reinforcing ring arranged in the original drum is changed into two. The width of the two stiffening rings is half of that of the original reinforcing ring and the height is the same as that of the original strengthened ring. By changing the position of the two strengthening rings, the effect of the strengthening rings is studied.

The distance between the two stiffening rings is 0 ,1/100~1 / 2 of the radial plate spacing, and the relationship between the distance between the two stiffening rings and the maximum displacement in the middle of the roller is discussed by simulation experiments. The experimental data are shown in Table 2:

The fitting curve shows that the maximum deformation of the middle position of the driving drum decreases first and then increases with the increase of the distance between the two strengthening rings. When the spacing of the stiffening rings reaches 1 / 7 of the spacing of the spoke plates, the maximum deformation reaches the minimum $0.28583mm$ .The functional relationship between deformation and spacing is:

$$f = 0.2021 \cdot m^4 - 0.1895 \cdot m^3 + 0.08225 \cdot m^2 - 0.01159 \cdot m + 0.2864$$

m ——Stiffening ring spacing / radial plate spacing

Tab.2.Deformation of the drum under the action of double reinforcing rings with different spacing (unit:mm)

m	0	1/100	1/90	1/80	1/70	1/60	1/50	1/40	1/35	1/30	1/25	1/20
deformation(mm)	0.28639	0.28625	0.28626	0.28629	0.28624	0.28621	0.28641	0.28623	0.28619	0.28615	0.28606	0.28602
m	1/15	1/13	1/12	1/11	1/10	1/8	1/7	1/6	1/5	1/4	1/3	1/2
deformation(mm)	0.28596	0.28579	0.286	0.28594	0.28597	0.28592	0.28583	0.28606	0.28629	0.2865	0.28715	0.29013

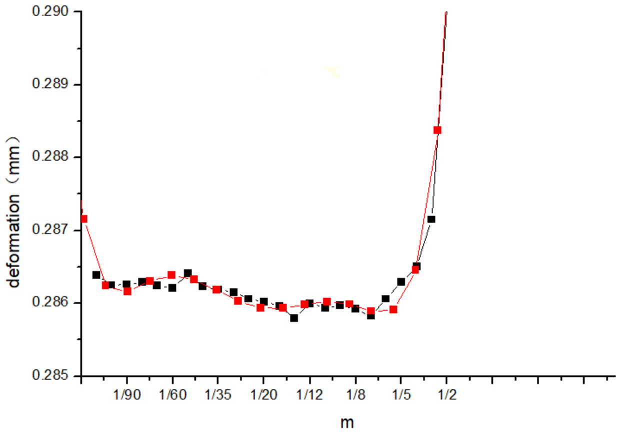


Fig.15.Data fitting curve

4. Summary:

Through the finite element analysis of belt conveyor transmission drum, especially the simulation study on the effect of rectangular stiffening ring inside the drum, the following conclusions are obtained:

1. Placement of rectangular stiffening rings in the inner part of the transmission drum can reduce the maximum deformation of the shell.

2. When the width of the single rectangular stiffening ring is 4 times of the shell thickness and the height is 5 times the thickness of the shell, the strengthening effect is the best.

3. The effect of double stiffening rings increases first and then weakens with the increase of the spacing between them. When the spacing of double reinforcing rings reaches 1 / 7 of the distance between two plates, the effect is the best.

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